



Large-scale, high-resolution wind resource mapping for strategic environmental assessment and wind farm planning and development

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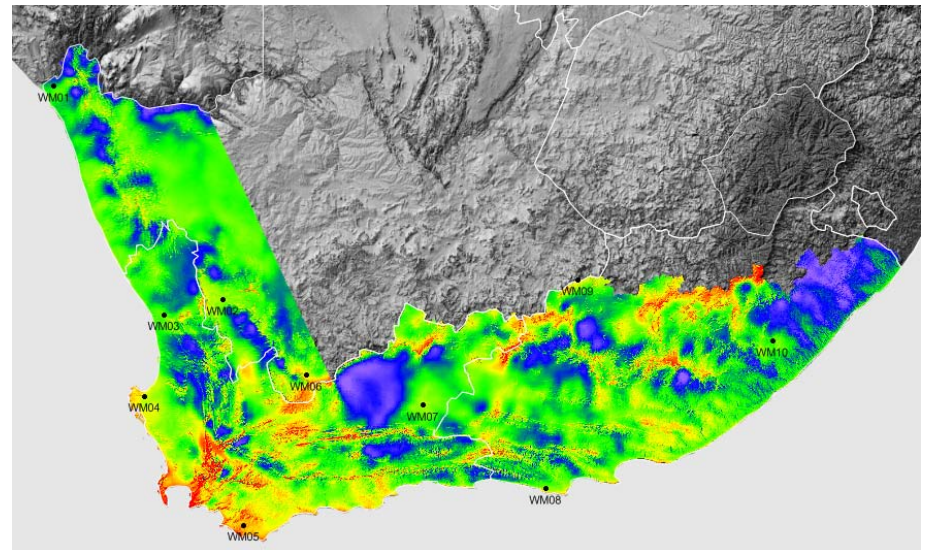
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Large-scale, high-resolution wind resource mapping for strategic environmental assessment and wind farm planning and development

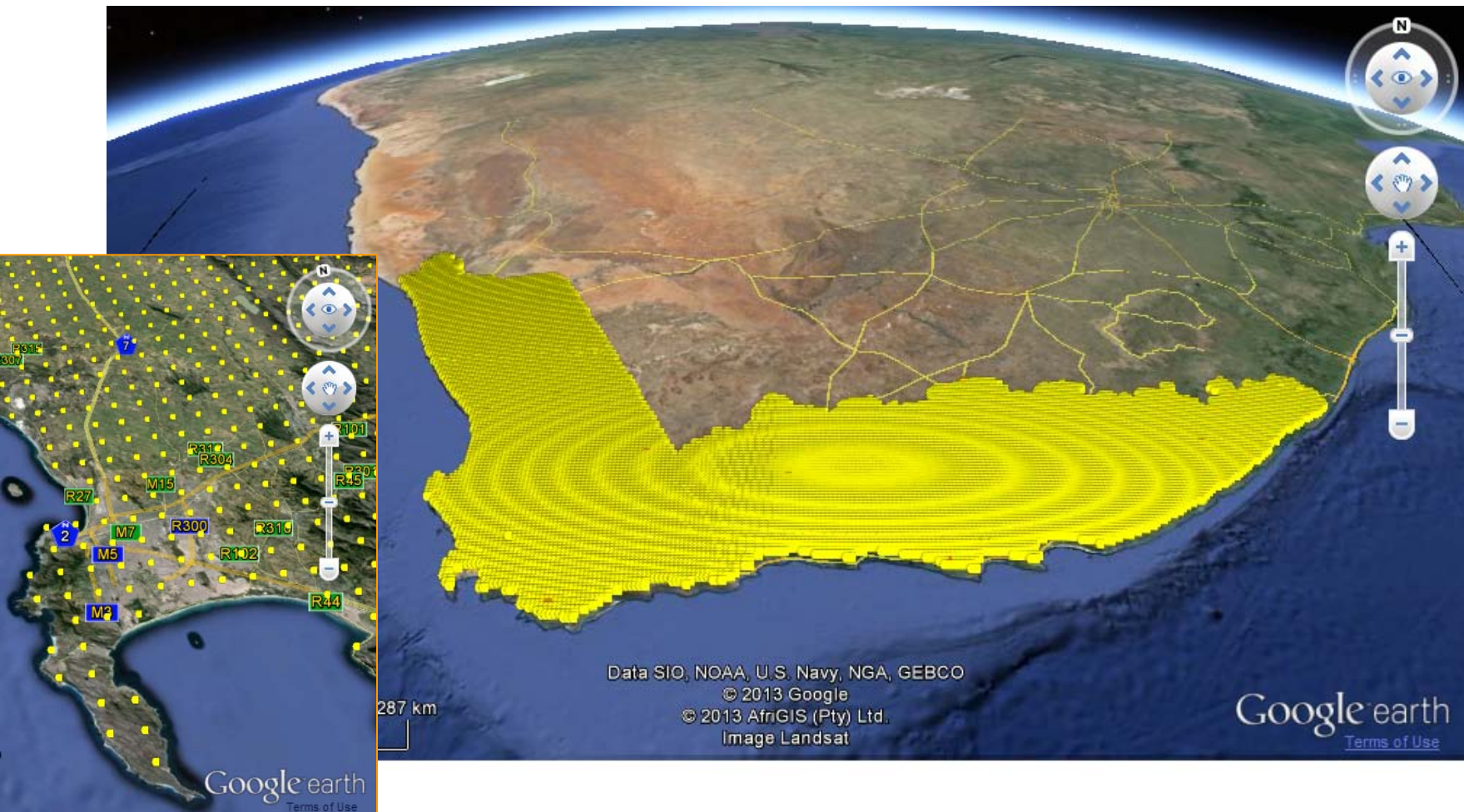
Niels G. Mortensen & Jens Carsten Hansen
DTU Wind Energy

Eugène Mabilille & Yvette Spamer
CSIR

Windaba 2013
Cape Town, South Africa

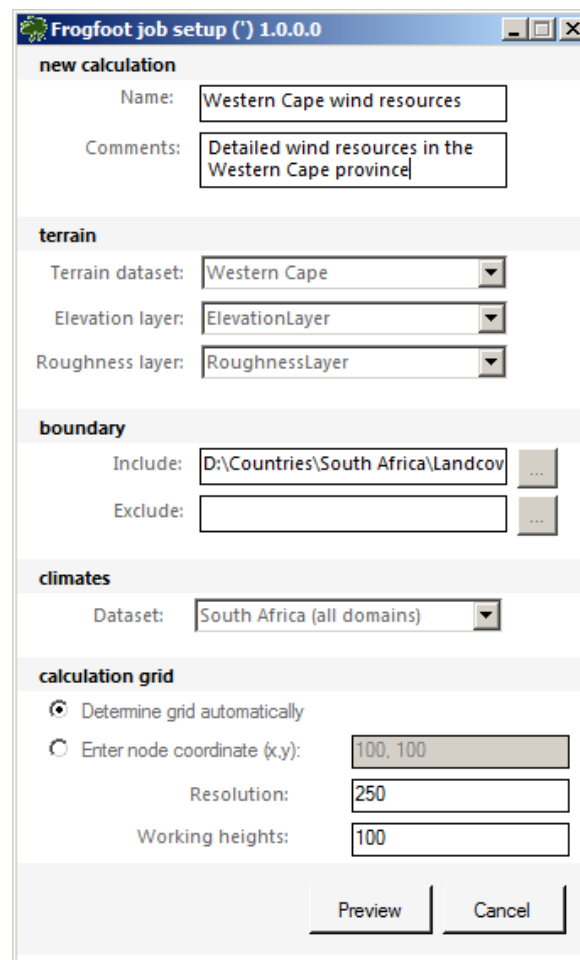


First Verified Numerical Wind Atlas 2012



New wind resource mapping methodology

- *Frogfoot* implementation of WAsP
 - Database of wind climates
 - Database of elevation maps
 - Database of roughness maps
- Principle of operation
 - Batch mode operation
 - Distributed computing
 - Wind atlas interpolation to every prediction site.
 - Results in MySQL database
 - Export to GIS formats
- WAsP standard modelling
 - Industry-standard model
 - Linearised flow model
 - Default parameters



Frogfoot job setup ('') 1.0.0.0

new calculation

Name: Western Cape wind resources

Comments: Detailed wind resources in the Western Cape province

terrain

Terrain dataset: Western Cape

Elevation layer: ElevationLayer

Roughness layer: RoughnessLayer

boundary

Include: D:\Countries\South Africa\Landcov

Exclude:

climates

Dataset: South Africa (all domains)

calculation grid

☒ Determine grid automatically

☐ Enter node coordinate (x,y): 100, 100

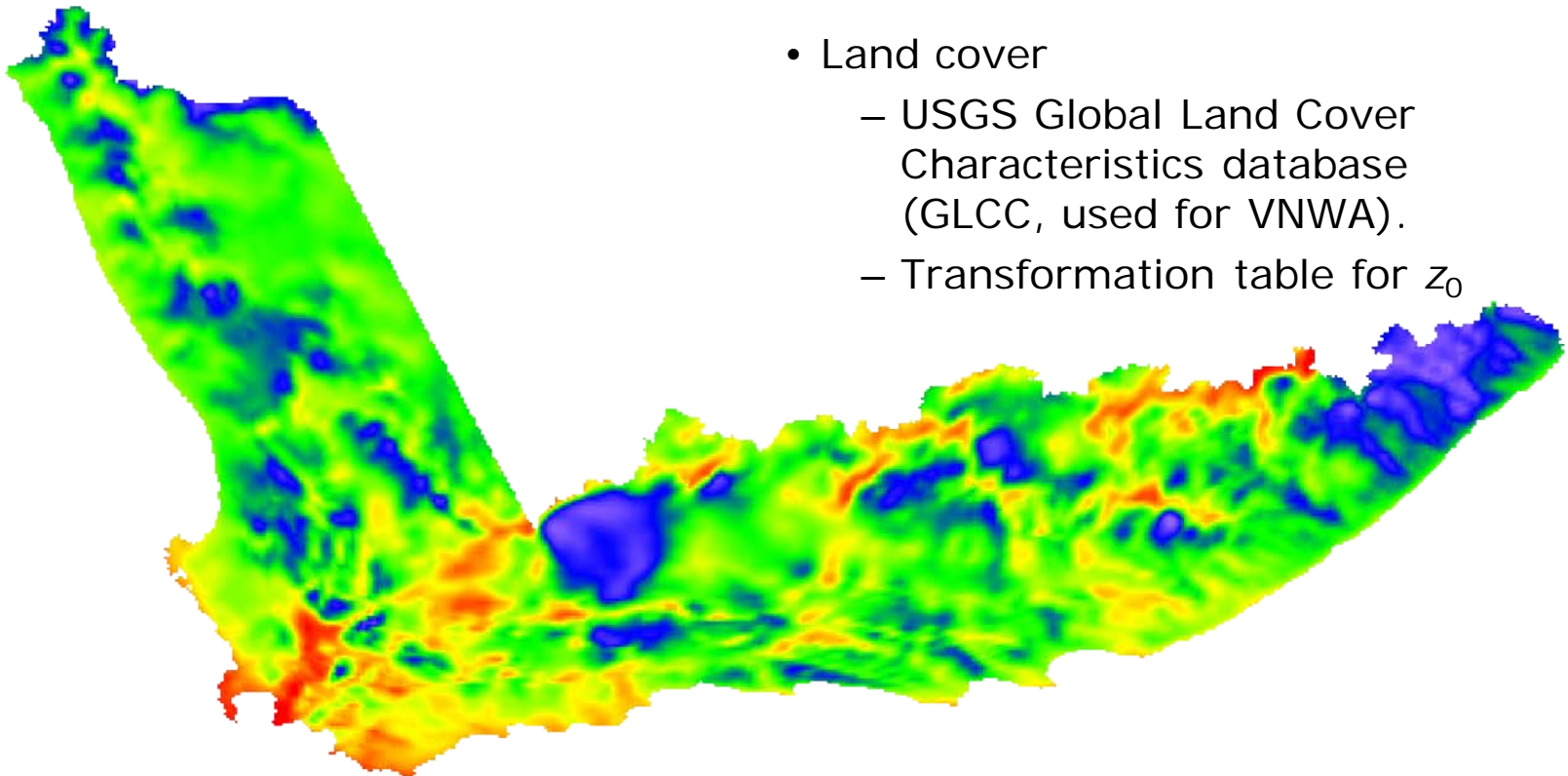
Resolution: 250

Working heights: 100

Preview Cancel

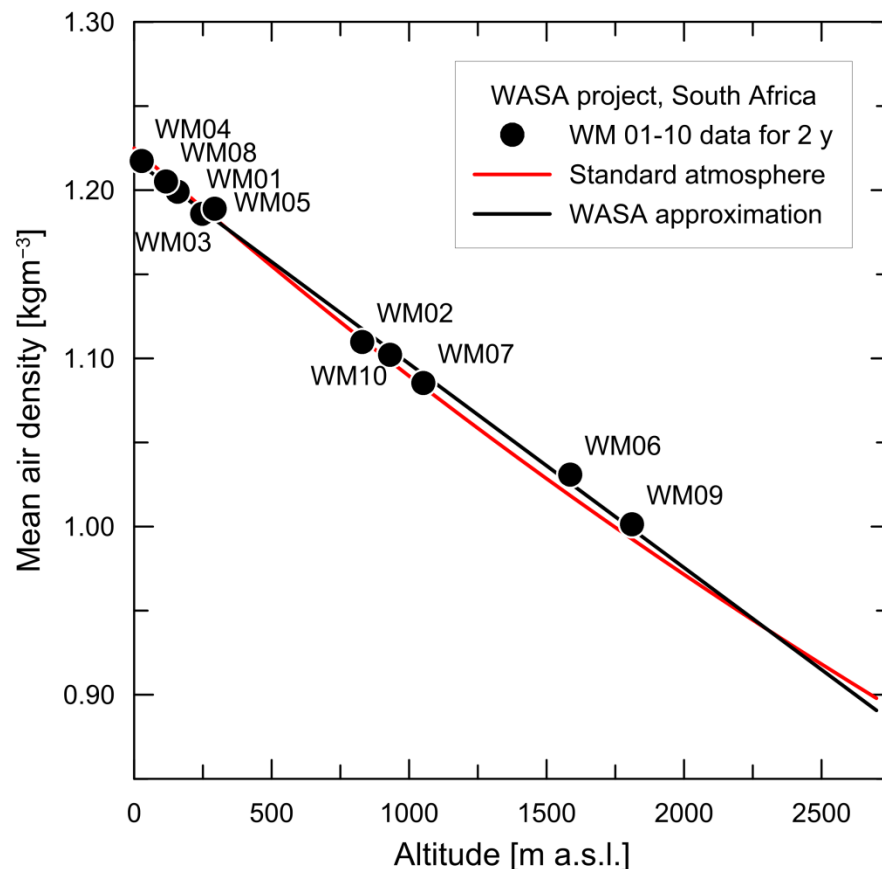
Available input data for modelling

- First Verified Numerical Wind Atlas
 - KAMM mesoscale model
 - Virtual mast for every 5 km
- Elevation
 - 20-m height contours from 1:50,000 South African topographical maps.
- Land cover
 - USGS Global Land Cover Characteristics database (GLCC, used for VNWA).
 - Transformation table for z_0

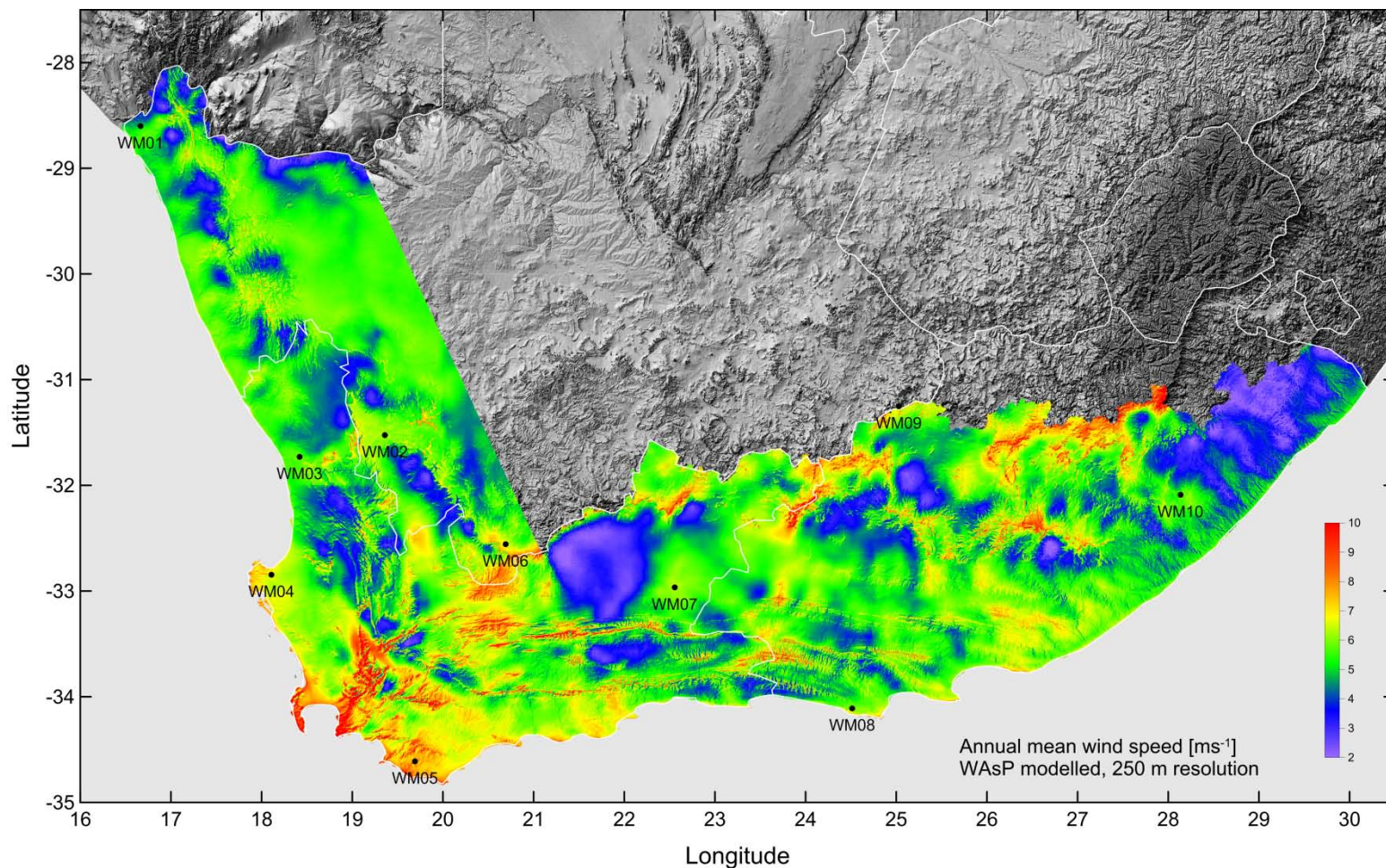


Output data in public domain

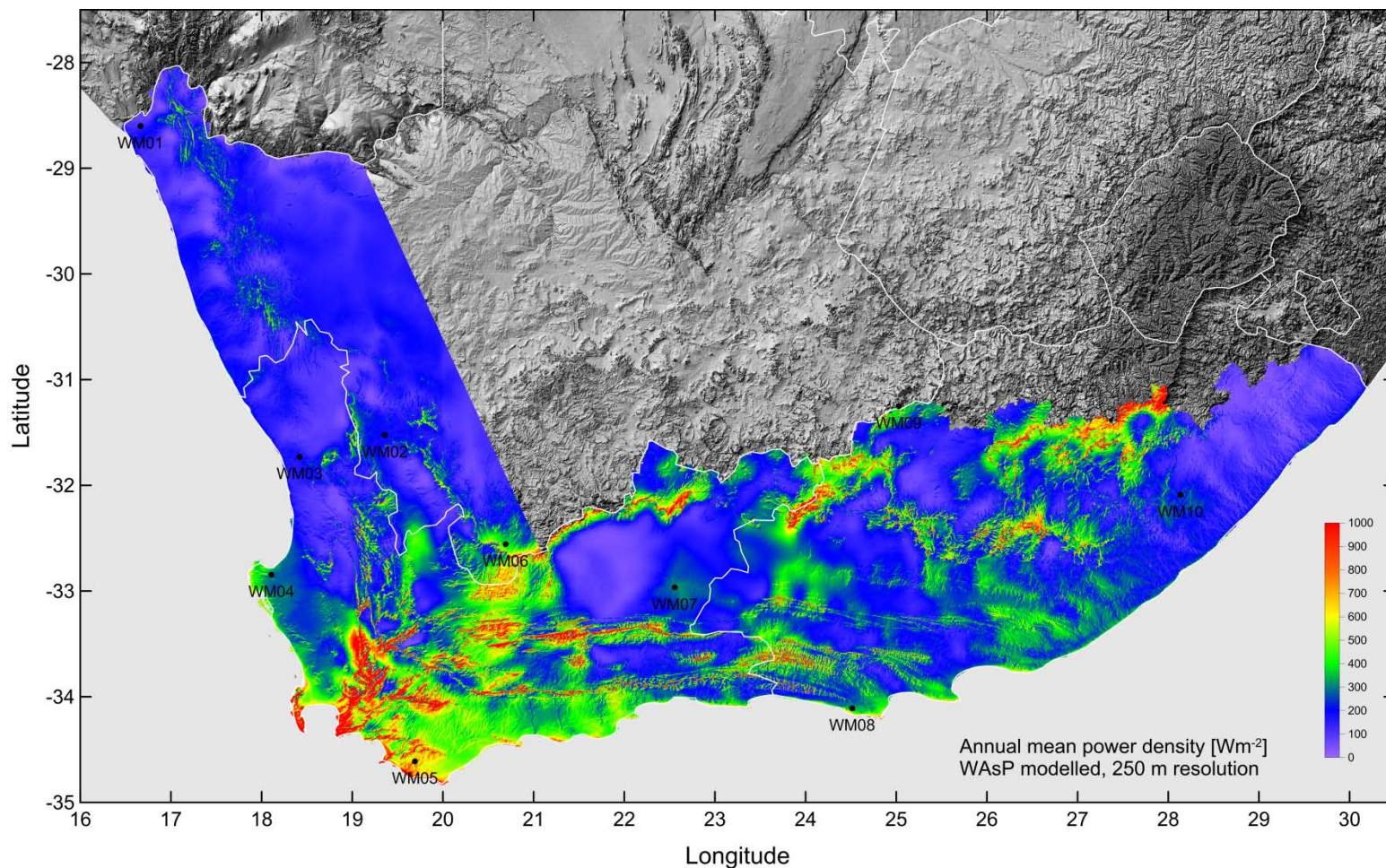
- Common characteristics
 - 250 × 250 m grid results
 - Modelling resolution ~1 m
 - 100 m above ground level
 - ArcGIS ASC output format
- Mean wind speed U
 - 10 min average in $[\text{ms}^{-1}]$
- Mean power density P
 - 10 min average in $[\text{Wm}^{-2}]$
 - Site-specific air density
- Elevation z
 - Meters above sea level $[\text{m}]$
- Ruggedness index RIX
 - WAsP standard parameters



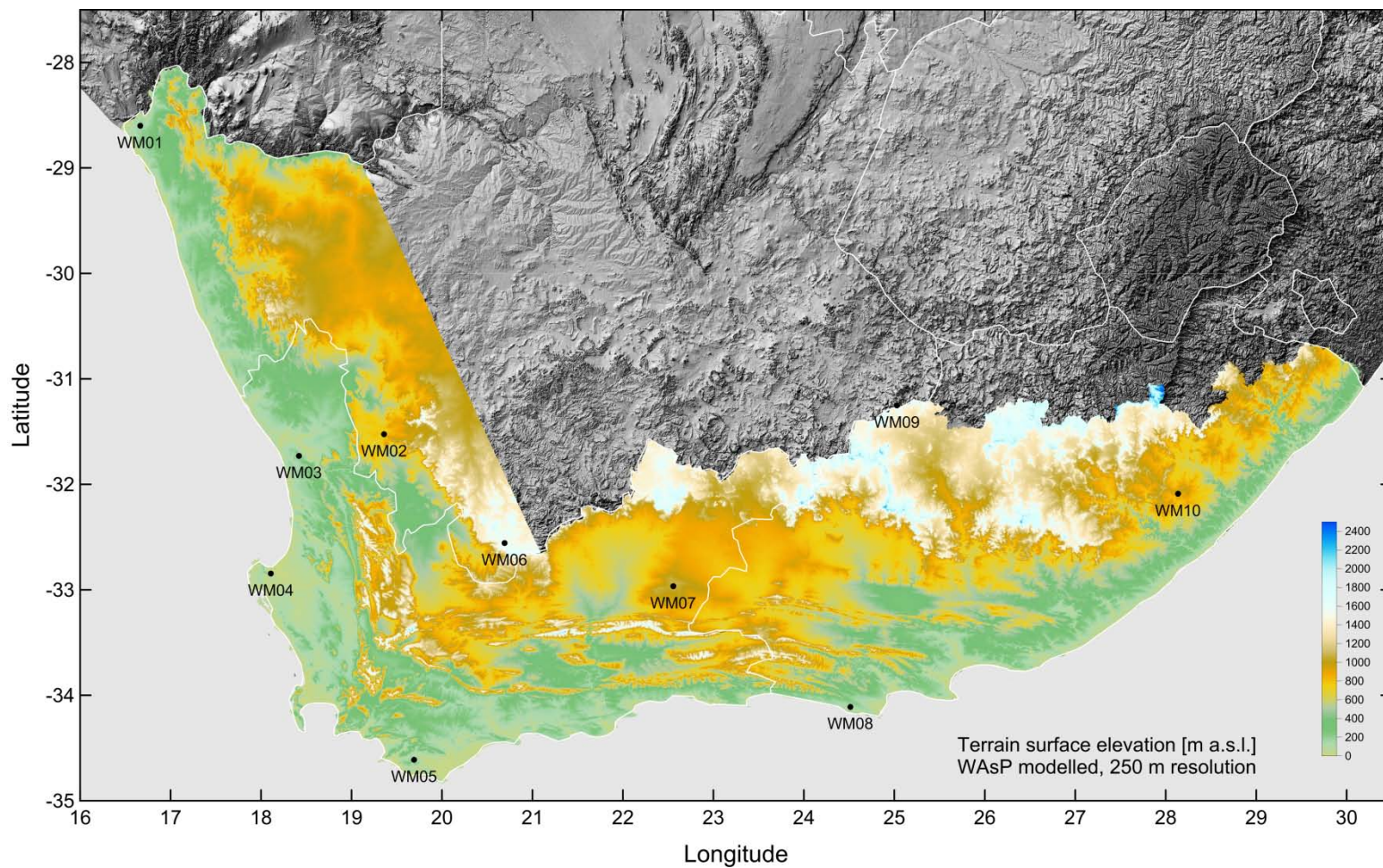
WASA wind resource @ 100 m – wind speed



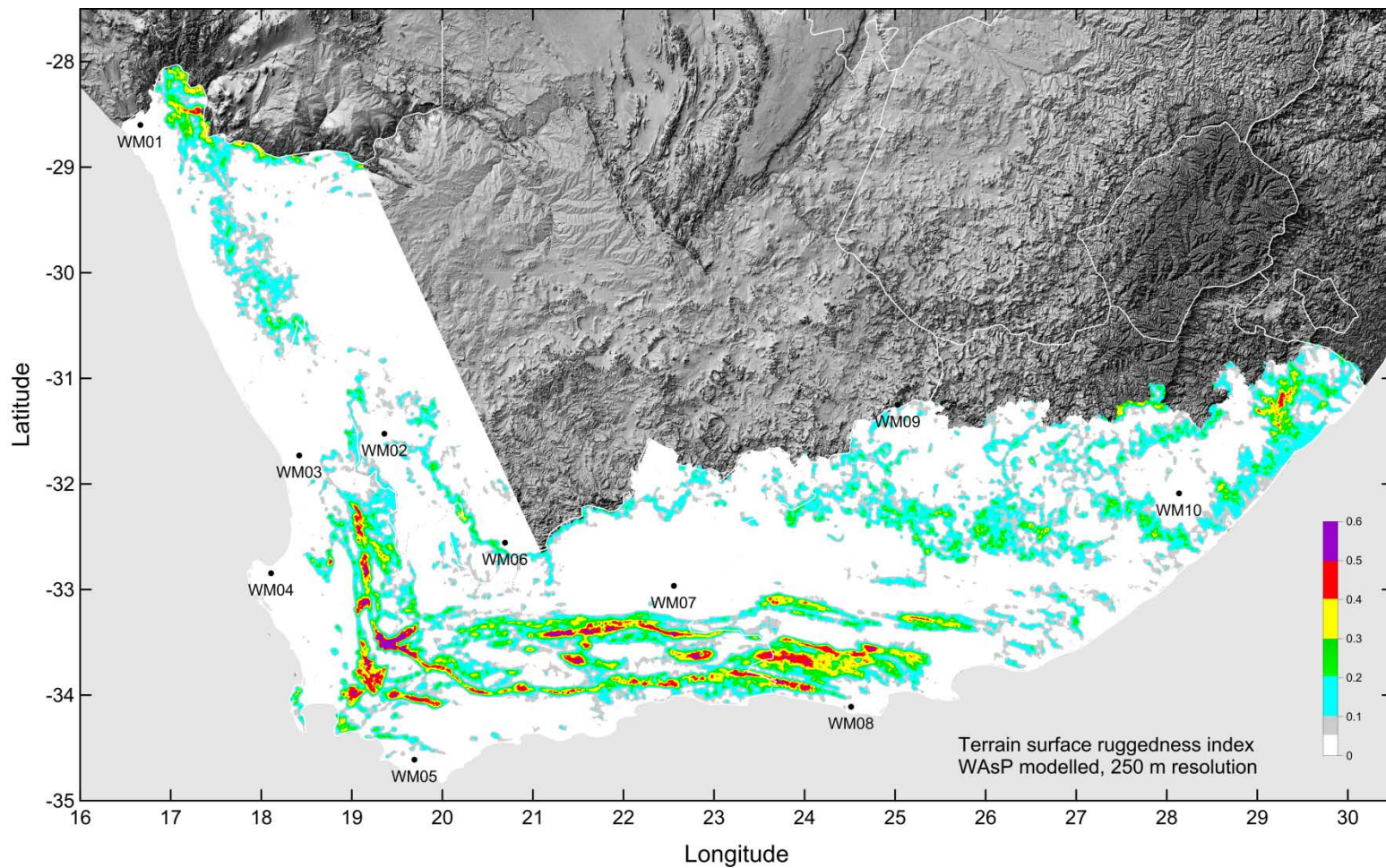
WASA wind resource @ 100 m – power density



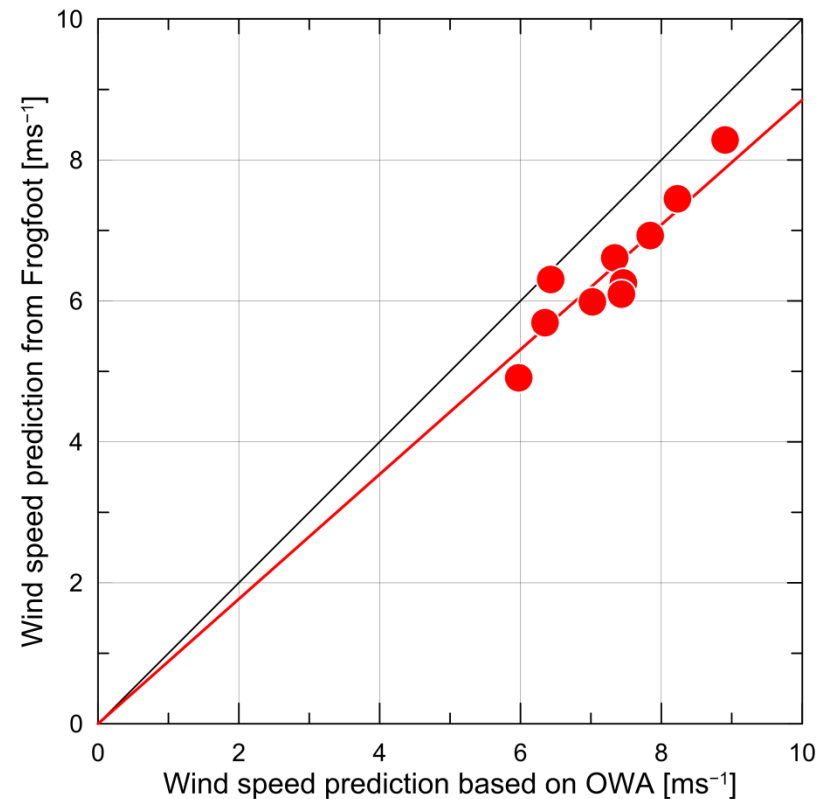
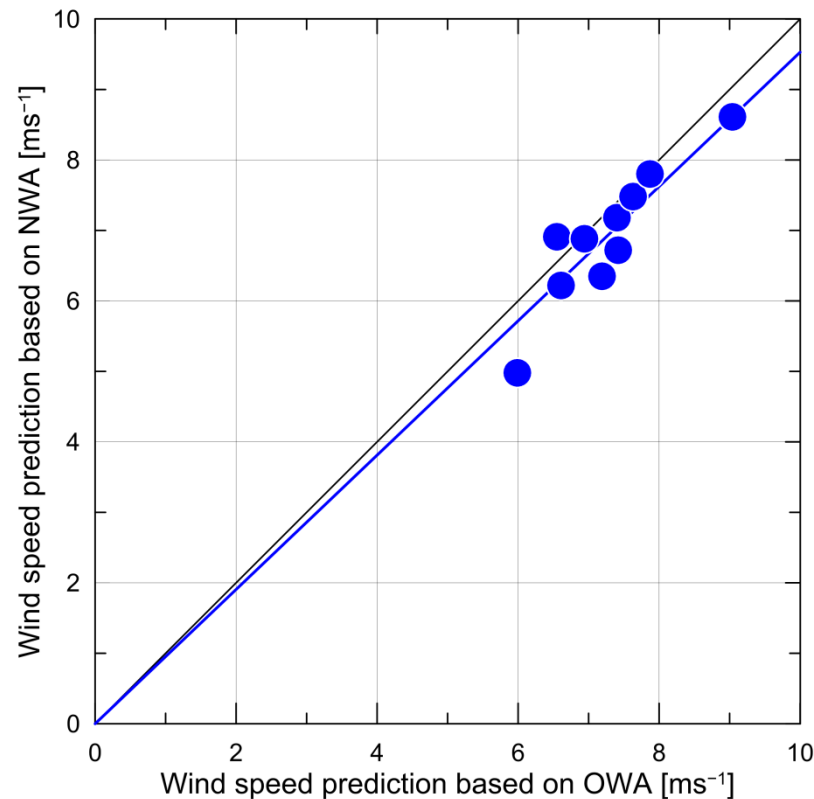
WASA domain terrain elevation



WASA domain terrain ruggedness index



Verification against wind measurements @ 10 masts

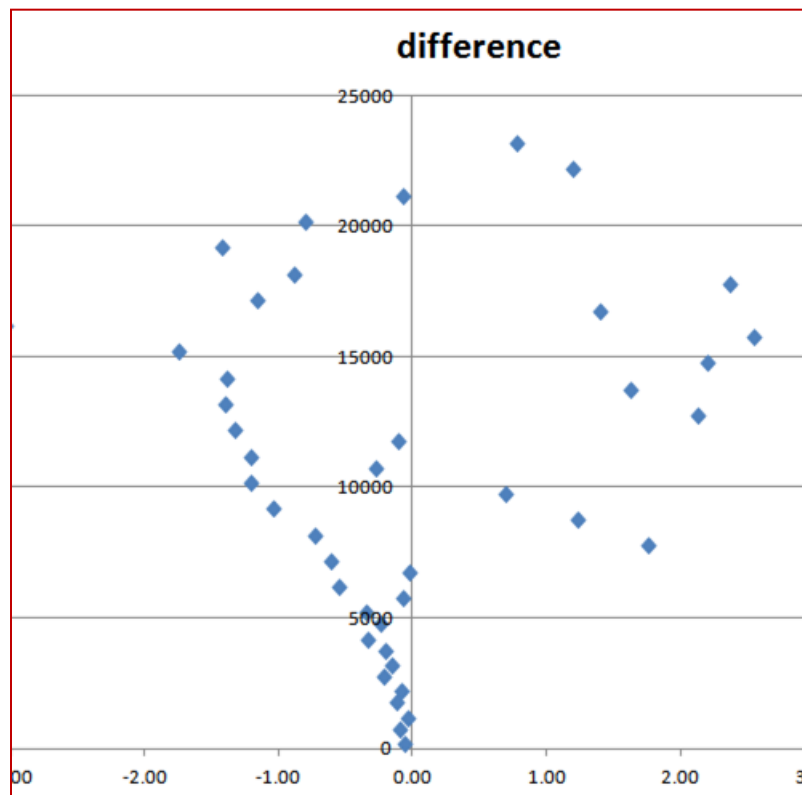


- First Verified Numerical Wind Atlas compared to observed winds (2y).
- *Testing wind-climatological inputs*

- Frogfoot large-scale calculations compared to observed winds (2y).
- *Testing wind + topographical inputs*

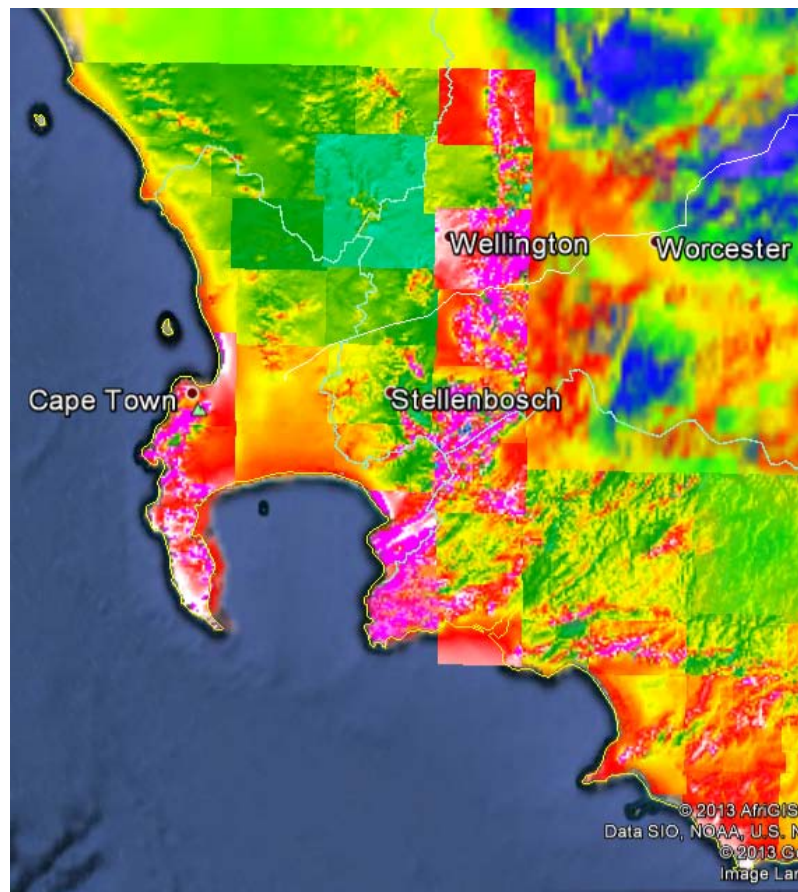
Further quality assurance

- Manual vs. automated approach
 - Comparison of software tools
 - Coordinate systems check
 - Coastlines and masks check
 - Elevation data check
 - Visual inspection of tiles of wind resource estimates.
 - Difference between resource estimates at similar points.
- Final data sets
 - Unedited and not limited
 - Extreme power density values
 - Includes blank nodes too
 - Editing sometimes necessary



Detailed wind resource mapping

- 250-m Frogfoot results
 - Standardised set-up
- User-generated maps
 - any scale and resolution
- Recommendations
 - Tile size – keep small
 - Site-specific parameters
 - Detailed elevation maps
 - Detailed roughness maps



Metadata documents for wind resource data sets

- Metadata for data sets
 - Data set specifications
 - Data provider
 - Contact information
- Data set parameters
- Coordinate system
- Technology (models & data)
- Detailed notes
 - Purpose
 - Methodology
 - Limitations
 - Available documentation
 - Acknowledgements
 - Disclaimer
 - Four maps of U , P , z and RIX

- Limitations
 - Operational envelope of WAsP
 - Verified numerical wind atlas (KAMM mesoscale model)
 - Input topographical data
 - Complex terrain (RIX > 5%)
 - Built-up areas
 - Forested areas

The wind resource maps are subject to change without notice if and when more accurate and reliable data, models and procedures become available.

Wind farm planning and development

- Identification and ranking of potential wind farm sites.
- Initial analyses and design
- Project planning
- Pre-feasibility studies
 - Resource assessment
 - Some site assessment
- Design of measurement campaign
 - Number of masts
 - Siting of masts
 - Orientation of sensor booms
 - Mounting of lightning rod and navigation lights.



Summary and conclusions

- Wind resources in WASA domain
 - Large-scale: $\sim 346,500 \text{ km}^2$
 - High-resolution: 250-m grids
 - Results in public domain:
wasadata.csir.co.za/wasa1
- Data sets specifically developed for
 - Planning and Strategic Environmental Assessment
 - WF planning and development
- Comprehensive verification and QA
 - Software development phase
 - Manual checks in several areas
- Wind resources pt underestimated
 - VNWA on average 5% too low
 - Topo-data means another $\sim 5\%$
- Wind resource maps preliminary
 - Strategic environmental assessments in 2013
- Updated WASA results April 2014
 - Updated mesoscale results
 - More detailed elevation maps
 - Updated land cover maps
 - Adjusted roughness lengths
 - Verification for 3y @ 10 masts
- Updated wind resource maps too!
 - U , P , z and RIX as shown today
 - Land cover and roughness (z_0)
 - Best practice and guidelines
- All WASA results will be presented at public workshops in April 2014.

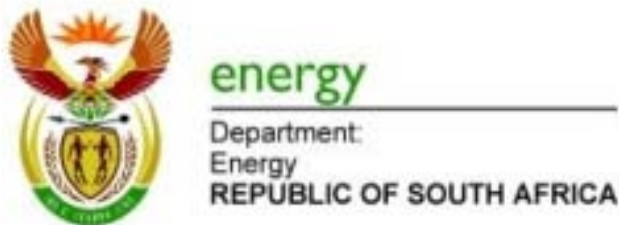
Acknowledgements

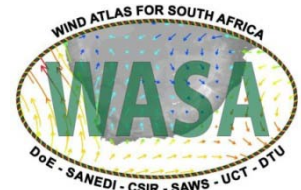
The Wind Atlas for South Africa (WASA) project is an initiative of the South African Government – Department of Energy (DoE) and the project is co-funded by

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- Royal Danish Embassy

WASA Project Steering Committee:

DoE (chair), DEA, DST, UNDP, Danish Embassy, SANEDI





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WASA download site

wasadata.csir.co.za/wasa1



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